PUBLICATIONS
OF THE
Wyoming Historical and Geological Society.
No. 1.

MINERAL COAL.

TWO LECTURES

BY

VOLNEY L. MAXWELL, ESQ.,

READ AT

INSTITUTE HALL, WILKES-BARRE, PENN'A.,

In February, 1858.

Fourth Edition.

WILKES-BARRE:
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PREFACE

TO FOURTH EDITION

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These lectures were written, not for publication, but to interest if practicable, highly intelligent audiences of ladies and gentlemen in Wyoming Valley—themselves well acquainted with many interesting matters connected with the subject, and therefore passed over by the Author. We were then in the midst of the financial troubles of 1857–8, when even hope, for a long time to come, seemed crushed in the hearts of our people.

These misfortunes, and the erroneous history of the coal trade, then just widely published from another quarter, prompted the record of the following pages. They were re-published in New York; and near the close of 1860, a third edition, was issued in pamplet form from the office of "*United States Mining Journal*," a valuable periodical of that city. To that edition the Editor appended a notice in which he said:

"We reprint them now on account of the useful facts embodied, and because two years experience since, have most singularly verified all their predictions thus far. The Wyoming and Lackawanna coal field is next door neighbor to New York. Arrangements are being made materially to improve the grade of the Morris and Essex Railroad, and to extend it to the Delaware, but it will not stop there. It will be extended direct to Wilkes-Barre, the center of the coal field; for the best coal is now known to be in that region. The Scranton Company has leased coal mines south-westerly of Wilkes-Barre, and nearly seventeen miles south-westerly of Scranton, and are of course thus bringing their coal through the latter place. There is yet room for another large Coal Company, and if it should be formed and extend to Wilkes-Barre the road referred to, all other coal companies subsequently formed, must be content with the means of transportation thus provided."

This was in 1860. Happily now, in 1869, The Morris and Essex Road, extended to the Delaware, is receiving coal for New York, from the new road since made by "The Lehigh Coal and Navigation Company" from Wilkes-Barre to Easton; and from The Delaware, Lackawanna and Western Railroad at their junction. "The New Jersey Central Road" is also receiving coal at Easton from the Lehigh Valley Railroad, since made also from Wilkes-Barre to Easton. The New York and Erie Railroad Company has also since constructed a branch Road from theirs at Lackawaxen to Hawley, and Honesdale, where they receive coal from

Carbondale and Pittston; and the construction of another Railroad has recently been commenced by the same Company, to be extended from their road near Lanesboro' into the Wyoming Valley. And besides these, the Pennsylvania and New York Canal and Railroad Company have now their Canal and Railroad just finished, carrying coal, side by side, from Wilkes-Barre and Pittston mines to western New York, and even to Chicago and Milwaukee.

There being so many competing lines of transportion, it would seem the demand for coal might be easily supplied at reduced rates. Why not? Simply because of increased demand for the article; adverse interests and illegal combinations of labor against—even its own *ultimate* interests.

If the duty on imported coal shall be released by the Government, not a pound less of our Anthracite will be used; for it is the superior quality of the Anthracite—not the duty—that keeps the Nova Scotia, and other bituminous coal, out of market,—except for a few special purposes. Yet, for the sake of all other business, the price of the Anthracite ought to be reduced—else the consumers in New York city and the east must supply themselves by an efficient coal and transportation company of their own.

MINERAL COAL.

Familiar, as we all are in this Valley, with this great staple of its business and trade; and brought home to our firesides as it is, every hour of our lives; the keen edge of our own curiosity may well be turned by unceasing contact with so hard a subject.

Still, even among ourselves, the curious question is often started; an idea new or old, is thrown out as food for thought; and sometimes a crude incipient theory is hazarded by some adventurous mind, and for once becomes the subject of merriment, or of doubtful, hesitating discussion, and is soon forgotten. We can readily imagine, therefore, with what unfeigned curiosity an entire stranger to the subject, would examine the first specimen of mineral coal presented to his view. Its appearance alone, would excite his close attention. The fact that it is used so extensively for fuel would add a deeper interest to the article; and, that it is found in so great abundance, evidently laid up in store for man between the rocks of the earth, would lend a still deeper interest to the mysterious subject. How could he resist the promptings of a curiosity thus excited? And with what zeal would he inquire and demand a knowledge of every fact respecting it. What is Mineral Coal? What is its substance? Of what material is it composed? Are questions that would first arise in the mind of such an inquirer; and if he were only told that it is composed almost wholly of carbon, he might feel but very little enlightened.

To pursue the subject further, he would have to learn, or to recall to mind the fact, that the early Chemists gave the name of carbon, to all that part of common charcoal which *burns*; and that they thus attempted to distinguish between its main inflammable substance and its impurities found in its ashes after combustion. But this explanation might still be unsatisfactory. He might know, or think, that these impurities were accidental; that they had been carried into the wood by the ascending sap of the original tree; for in the sap of wood, the Chemist finds those impurities, consisting of certain salts of the earth, iron and silex—all afterwards found to compose the ashes of the coal. He sees, then, that in charcoal he has not the pure, and unadulterated carbon; and how far its appearance, properties, and characteristics are modified or changed by these impurities, is impossible for him to tell. We know

that iron is the great coloring matter of nature; in which she dips her mysterious pencil, and paints all her handy-work; but how the salts and the silex modify the nature of carbon no one knows. Charcoal is not, however, the pure carbon the inquirer desires to see, and if his curiosity is to be gratified, he must go to the precious diamond of the jeweler.

In that brilliant gem we behold a substance, in appearance, as different from charcoal as possible; and, to the eye and all our senses possessing not a single one of its properties. Diamonds are found generally in the loose, diluvial sands of rivers and plains, apparently washed from mountains of granite and other primitive rock. So rare are they that one weighing less than an ounce was sold to the Duke of Orleans for more than a million of dollars. Another, weighing only about two and a fourth ounces, is now among the crown jewels of Queen Victoria, and cost the British Government nearly nine millions of dollars; but diamond merchants estimate its real value at three millions. So hard are they, that no other substance has been found to scratch or cut them; and the consequence is, that they are shaped, and polished, only by rubbing them together; or by using upon one the grit of another, pulverized for that purpose. As to light, it possesses a high refractive power bespeaking its vegetable origin. It is a non-conductor of heat and electricity; is unaffected by acids or alkalies; and will not melt in any heat that can be applied. Its beauty, as a gem, consists in its power of apparently absorbing the sun's light, and of giving it out afterwards in beautiful phosphorescence. In a word it is pure crystallized carbon,—so very different from charcoal in all its aspects, that we must have the very strongest proof before we can admit that they are, substantially, one and the same substance: And what is the evidence of this fact?

The first test is a very simple one. If a piece of diamond is inclosed in a wrought iron shell, or ball, and the whole heated red hot; upon opening it nothing is found; not a particle of sediment or ashes; and nothing of the diamond is to be seen; but, upon examining the inside of the iron ball, its nature is found to be entirely changed. Before, it was wrought iron; soft and mallable; now it is steel, or more properly like cast iron; showing clearly, that the diamond is but pure carbon; and that it has entered into the iron and changed its nature, as carbon always does; for if a small piece of charcoal is placed in the ball, and heated as before, precisely the same result follows; except that the impurities of the charcoal are left in the shell as ashes; while the nature of the iron is changed, as in case of the diamond.

There is another test to be added to the foregoing and it is far more interesting and decisive; but, to understand it, we must bear in mind some of the prominent qualities of oxygen.

When pure, oxygen is a transparent, colorless gas; which no degree of cold or pressure has ever reduced to a liquid state. It is the most widely diffused, and the most important of all the simple elements. It constitutes by weight, more than one fifth part of the whole atmosphere. Of all the waters of the globe, it forms about eight-ninths; and in all probability constitutes about one-third part of all the soil and rocks of the whole earth. Of all known substances, it has the widest range of affinities; and this strong and varied disposition or power of uniting itself,—for different purposes,—with almost every other substance, seems to stamp it with the character of a discriminating intelligence. Its embrace, however, is one of life or of death. With this power of combination, it builds up and tears down, and seems ever at peace and at open war with the other elements of nature. It helps to construct the wonderful fabric of our bodies; and sustains us in life and in health; but, the functions of our systems once fatally disturbed, it turns upon us with a destructive power; feeding upon the carbon of our flesh until exhausted and then assailing the carbon of the brain, when the delirium of death intervenes and closes our existence here. But we must now look more carefully at some other of its operations.

If a piece of sheet iron is exposed to the weather, it is soon destroyed by rust. The oxygen of the air, the dew and the rain, unites with the particles of iron, and one by one, changes them into the oxide of iron: and Chemists describe this change briefly by the simple expression, that the iron is *oxydized;* in other words—by this process the iron is *burned up;* and yet by a process so slow, that neither perceptible heat nor light is evolved. That the process of combustion is only the oxydation of the substance consumed, is proved by the following facts.

A small measure of water may be entirely decomposed by a galvanic battery, and thus its original elements are found to be two distinct gases—oxygen and hydrogen; each differing from the other in almost every particular, except their gaseous form; and yet, when again mixed in the same proportion as in water, they retain that form, and do not become water by mere mixture. To reduce them to water, fire must be applied; and if this be done, only by a heated wire, an explosion occurs, and the whole is instantly changed to water,—a substance widely differing from both the gases of which it is composed.

Now what is the chemistry, or philosophy of this change? Clearly this: the hydrogen gas is only oxydized; and the oxygen has united with it *so rapidly* as to disclose the latent heat in both gases, and in such abundance as to produce light. This most interesting fact—the existence of latent or hidden heat in all substances—is proved by a simple, old-fashioned

instrument used before the days of the lucifer match and for the same purpose.

A blow upon this instrument would condense two or three cubic inches of air, into a space less than half of a small pea, and the tinder previously deposited, would take fire in consequence. That two or three inches of summer air should contain heat enough to light the tinder might not seem so very strange; but to see the same fire lighted by the condensation of out door air in winter, so cold as to freeze everything within its power, does seem strange, and can only be accounted for by the existence of latent heat in all substances yet tested.

By putting such facts and developments as these together, and by reading their meaning aright, we are enabled to see clearly what the process of combustion is; it is the oxidation of whatever substance is burned. If a piece of wood is placed in a vacuum where no oxygen can reach it, it will not burn; but if lighted in the open air, the oxygen of the air unites with the carbon of the wood, and evolves the talent heat of both, so rapidly as to be seen and felt, sometimes to our loss and suffering.* It is to this love or this affinity of oxygen for carbon that we are indebted for all our fires; and for the large amount of comfort and happiness they bring to us, in various ways. These truths, of late years, have become a part of the mere alphabet of chemistry; but we must recall and bear them in mind if we would know what we are about; and with the aid of these few facts we shall be enabled to comprehend more clearly another test of the nature of the diamond.

Pure oxygen, being heavier than atmospheric air, can be poured into a glass jar, where it will remain for experiment. In a jar thus filled with oxygen a piece of diamond may be put; and then if you turn upon it the focus of a powerful lens or burning glass, the diamond will take fire, and burn with a lambent flame until it is consumed; but what is the product? Nothing but carbonic acid gas; which, being also heavier than the atmosphere, will remain in the jar, taking the place of the oxygen consumed. The oxygen has united with the carbon of the diamond and thus formed the carbonic gas. And this is proved, not only by the nature of the change which has taken place, but by substituting a piece of charcoal in place of the diamond precisely the same result follows the

*The more modern theory, is that heat is not a pervading fluid, substance, or element; but the *effect* of motion in the ultimate particles of matter; that every such particle is separated from all others by a space as imperceptible to our senses as the single particle itself, yet a space sufficient to admit of its constant revolution and changes of position attributable to its polarity. If this be true, how are the particles of matter held together with such tenacity? We may answer—by the attraction of cohesion; analogous to the power which holds the planetary system so firmly together, and yet allows each planet the freedom of two exceedingly rapid motions. We can divide and scatter the particles of iron, but not a planetary system; and certainly this theory explains more of the phenomena of nature than the older one referred to above and in previous passages. If it is a correct theory, then we can only say of combustion that the rapid union of oxygen and carbon so accelerates the motion of their ultimate atoms as to produce the effects called heat and light.

same experiment; save that the charcoal leaves a particle of ash in the jar; and if, in the place of charcoal, a piece of Anthracite coal is used, the same result is again produced. Differing, as these two gases do, so widely from each other, these experiments are of great importance. They present undeniable evidence that the precious diamond is the only specimen of pure carbon to be found, seen, and handled; and that charcoal is the next purest carbon, having only about two or three per cent. of impurities.

In like manner careful chemical analysis, proves that Anthracite Coal is the next purest carbon, in large quantities. A fine specimen of it contains about ninety-five per cent of carbon, while about five per cent. of it is found to consist of water and sand; with sulphur, alum, iron, &c., in various but very slight proportions.

From this the Bituminous Coal differs essentially. If you were to go to the neighboring gas works you would see it there in the process of distillation, and the process itself; the chemical changes, the object, the mode of its accomplishment, and the results, would all afford ample material of themselves for an interesting and instructive lecture; but we can notice here only a very few leading facts that bear directly on the main subject.

The main products of this distillation are the gas, the tar, and the coke. The gas, collected in the Gasometer and distributed through the town, is called carbureted hydrogen. Pure hydrogen, uncarbureted, with oxygen, forms the elements of water; and in some of the Bituminous Coals, there is enough of water and other substances containing hydrogen, to render their distillation profitable for the purpose of light; and of these substances, consisting of resins and other matters, there is about twenty-five per cent., usually, of the whole; leaving only about seventy-five of pure carbon in Bituminous Coal. In its pure state, hydrogen gas burns with a faint light and a bluish white flame; and it is rendered useful for lighting purposes, only by the carbon it carries off from the coal. It is this carbon, mixed with the hydrogen, that gives it the name of carbureted hydrogen, also its high illuminating powers; and its grosser particles sparkle in the flame of our gas lights.

Besides the gas a large quantity of tar is produced and used for economical purposes, and lastly the coke, taken out of the retorts after the gas and the tar have been expelled. This coke is the remaining unconsumed carbon of the coal, and resembles charcoal in many respects. Now if wood, instead of Bituminous Coal, is put into the retorts and treated in the same manner, the same products, substantially, are obtained. The gas is the same but more difficult to purify, and is hardly as good for light. The tar is very much the same, though dif-

fering somewhat in its qualities; and instead of carbon in the form of coke, we have it in the form of charcoal.

Bituminous Coal then, upon distillation, produces carbureted hydrogen gas, tar, and carbon in coke; while wood, treated in the same manner, produces the same gas, a similar tar; and also carbon in charcoal.

These resemblances long ago produced in the minds of scientific men strong impressions that wood was the origin of mineral coal; and further investigations since have deepened the impressions into the strongest convictions.

For instance,—charcoal, pure and perfect, is often found in the middle of Anthracite Coal and in the deepest beds; and sometimes the charcoal seems to run almost imperceptible into the Anthracite. Again, if a thin flake of Anthracite, rubbed down until it is semi-transparent, is placed between a microscope and a powerful light, the vegetable structure of its cells is unmistakable; for the cells are characteristic of the labors of the Creator in the wood of forests, just as the cells of the honycomb are characteristic of the labors of bee.

Doct. McCulloch, also, by heat and great pressure, converted wood into a substance so strongly resembling Mineral Coal, that he no longer doubted the vegetable origin of the latter; and last of all, beds of Cannel Coal have been found to contain whole trees, with roots, branches, leaves and seeds, converted into perfect coal of that quality. It differs from other coal principally in its form, weight and structure; and yet it is so clearly nothing but Mineral Coal, that all further question as to the vegetable origin of the latter, seems to have been abandoned. Even the unlearned workmen, seeing so much evidence of this in the vegetable impressions of the coal strata, and otherwise, are also impressed with the same convictions as to its origin. But this fact conceded, there are still many interesting questions to be solved. Where could all this vegetable matter, necessary to form such extensive coal beds, and so many of them have come from?

In this single coal field there are at least one hundred and fifty square miles of coal land; and in most of that area there are six or seven thick workable coal beds, whose united thickness cannot be less than sixty feet. The shape of the Valley; the evidence of its once having been a lake and the flowing into it of a large river have given rise to the impression in the minds of many, that the large amount of vegetation preserved in these coal beds must have been swept into it at different and remote periods by overwhelming floods. But such a theory cannot be correct. If it were, the coal instead of being nearly pure carbon as it now is, would have been mixed with sand, gravel, clay and stone in such large proportions as to have rendered the coal comparatively useless. There is indeed, abundant evidence of overwhelming floods or drifts;

but not of vegetable matter. The subject of such drifts has been the clay, sand and gravel which now compose the rocks intervening between the beds of coal. The vegetable matter composing the beds themselves is too pure to have been disturbed by such drifts, except to be covered by them; and the conclusion irresistbily follows, that the vegetation in question must have been buried upon the spot where it grew.

Our minds are prepared then to understand the next prominent fact bearing upon the question; and it is this: Under every coal bed, and immediately in contact with the coal, is always to be found a stratum of what miners call fire clay. Its thickness, hardness and color, of course vary. Sometimes, and generally in fact, it is found in the form of a slaty rock; but whatever its color or consistency; that same material is always to be found under every coal bed, whatever its thickness. Its nature is always that of a clayey soil; and undoubtedly it formed the *soil* in which the vegetation of the coal bed took root, and began to grow; for, on close examination, it is always found to be full of the fossil impressions of the roots and twigs of the coal vegetation, which once grew from its bosom.

These facts are suggestive; and our minds are naturally turned from them to the process of a coal bed's formation upon this theory; but it is not a mere theory, for we can still adhere to well known facts for its illustration. The formation of peat beds is strikingly analogous. We are not familiar with them in this region; but they are, in a great degree, the products of a species of moss called by botanists the sphagnum palustre. Like some other kinds of moss, its lower roots annually die, while the top continues to live and grow by sending out new roots above those decayed. In this way a years growth is annually added to the thickness of the bed; and this is so well understood by the workmen that in some localities where it is an object to preserve the bed, the sod containing this moss is carefully removed and after a stratum of peat of uniform thickness is taken from the bed for use, the sod is replaced that the bed may be renewed. In Bakewell's geology it is said that a peat bed has been known to grow nine feet in 30 years. The peat is cut out in blocks with sharp spades, stacked, covered and dried for fuel; and sometimes the water is pressed from it, which facilitates its drying, and renders it more compact and useful. It burns well when dry, and answers a good purpose for fuel. I have seen a specimen of peat from Canada. A portion of it seemed to be fibrous, as we would naturally anticipate; but the other end of the block, which doubtless was the lower end as it was in the bed, very strongly resembled bituminous coal in odor and appearance. Besides the moss, already referred to as the principal vegetable concerned in the formation of peat, there are about

forty others which help its growth in some degree; but they are all of small stature, mere weeds, rushes, &c., while the fossil remains of the coal flora exhibit about four hundred different kinds, of all sizes, from the smallest to those among the largest of trees. These facts, therefore, present a difficulty in the case of coal beds which does not exist in the case of peat; and yet this difficulty may be solved by another appeal to facts.

In the geological reports of New Jersey is a full and particular description of the cedar swamps in the southern part of that State. In such swamps there is generally a thick growth of timber, and the reports say, "the soil in which these trees grow is a black earth, or mud, varying in depth from two or three, to twenty or more feet, and is composed of vegetable matter, which, when dry, is easily burned; and the amount of ashes left is exceedingly small. In two trials which we made the amount of ashes left from the dry earth was only one and a half per cent. When this earth is opened to the sun and rain it decays rapidly; but when covered with a growth of trees, and so shaded that the sun does not penetrate to the ground, it increases rapidly from the annual fall of leaves, and from the twigs and small trees which die and fall. A log, sawed at both ends, was recently found entirely buried in the swamp, and was known to have been cut within the memory of men familiar with the place. Other trees are also found in great abundance, buried in the earth at all depths, quite down to solid ground. Men are annually engaged in digging them out, and converting them into rails and shingles. Some of these buried trees are found with the roots upturned, as if blown down by the winds; while others are broken off as if they had stood and decayed until too weak to support their own weight." Another significant fact is developed by this survey. It is found, that in the southern part of New Jersey, *the land is sinking;* and this is proved by portions of these swamps being now under sea water, with their trees yet standwhere they grew, but killed by the effect of salt upon them. Certainly, they never started into life, and grew to their present size under water; and therefore the land in that region must unquestionably have been sinking below its former level. Now, suppose these cedar swamps shall continue to subside, until their timber shall have all fallen, and the ocean shall have thrown over them beds of sand and gravel hundreds of feet in thickness, — what is to hinder their twenty or forty feet of black carbon being in time compressed, hardened, and converted into coal? All must see the probability of such a result—the almost certainty of it; for in England coal beds not only exist under the sea, but are mined for more than a mile under the ocean, in more instances than one. And if our minds yield to the probability of such a

formation, we can then understand why it is, that at the bottom of a coal bed, we find the ancient fire clay or soil in which its vegetation commenced filled with impressions of roots, and at the top impressions of leaves, twigs, &c., and along the roofs of some coal beds the fossil remains of trees, sometimes seventy or eighty feet long. Clearly, if a coal bed has been so formed, the bottom of it is exactly the place to find one, and the top to find the other.

We have seen that the mud of these swamps are full of trees, that have lived out their time and are thus buried beneath the surface. We know, also, their power of still resisting the elements of decay. In aid of this power, comes the preserving qualities of the carbon in which they are imbedded, and their exclusion from frost and the oxygen of the air,—the great enemy of their existence. Can they ever become mineral coal? We know not, it is true, the details of their future history, but we can look at the past. In beds of cannel coal, whole trees, of all sizes, with roots, branches, leaves and seeds, are found carbonized, and forming fair specimens of that kind of coal. Its name is an English corruption of the word *candle*, and is given to it because it burns with great freedom, affording an humble substitute for candle light in many a cottage home of England. There this coal was first discovered and characterized. It is also found in this country—in Kentucky, and in Beaver County of this State. In addition to this, there is the brown coal of Europe. Geologists speak of it as formed of "heaps of trees, buried by inundation, under beds of clay, sand, and gravel. The woody parts have probably undergone a certain degree of vegetable fermentation, under pressure of incumbent earth; and thus have become carbonized and consolidated. In some specimens the fibre or grain is perceptible in one part, while the other is reduced to coal. In such instances—and they are numerous—nature is seen in the act of making coal, before the process in completed. A large deposite of this coal exists in France, near Cologne;" and it is added by Bakewell, that "it extends several leagues, is fifty feet in thickness, and has trees imbedded in it."

We have thus endeavored to trace, step by step, the outlines and strong points of the evidence by which men, who have examined the subject carefully and thoroughly, have been convinced of the vegetable origin of mineral coal. In the minds of such men, it is now a settled question; but other questions of great interest, arise at once upon the foundations of this theory.

Here, in this valley, we have coal strata whose united thickness is, at least, sixty feet. We are all familiar with its solid structure; and if, as we suppose, it has a vegetable origin, its solidity must be owing to the great pressure of the overlying

earth and rocks. What then must have been the original thickness of those ancient vegetable deposits, which, thus compressed, present now such a great thickness of coal? The coal beds of Great Britain, not thinner than our own, cover nearly one-third of that island. Those of the United States, east of the Rocky Mountains, are supposed to cover an area of 133,000 square miles; and this is but a small part of all the coal in the world. Where then, we may well ask, could all this carbon, forming these vast beds of coal, have come from? The question may not be answered satisfactorily to every mind, but we are not without a guide in the inquiry.

A forest tree of the first class contains a large mass of vegetable matter. A portion of this can be placed in a retort and by heat all its resinous and volatile matter can be expelled, leaving its carbon or charcoal of the same shape and size as the piece of wood subjected to the process. And if it were practicable to subject the whole tree, just as it stands, to a similar distillation, we could then see at a glance its whole perfect anatomy, or frame work of carbon, and better realize the massiveness of the material. Applied to such a structure, the question—Where did all this carbon come from? has more of significance and difficulty. Carbon, with all the other elements was formed by the Creator, it is true; but here is a large towering column of carbon, that was not standing here a century ago: whence and how was it gathered up and raised into this elevated structure? We know that about the roots of such a tree there is carbon in the vegetable mold of its soil, but not enough within the sphere of its roots' attaction to build up such a noble column. Besides this, no diminution of the carbon at its roots is perceptible. On the contrary the tree itself adds its annual contribution to that deposit, increasing its thickness from year to year, as we have seen in the case of the cedar swamp; and this annual deposit is over and above what is annually retained in the tree. It cannot produce or cast off more carbon than it receives; and as it receives none from the ground on which it stands, we have forced upon us the conclusion, that all its carbon is derived from the atmosphere; that its leaves inhale it from every breeze; and yet, in the present atmosphere scarce a trace of it is to be found. We know that it exists; that myriads of living beings are continually breathing out a gas surcharged with carbon, and inhaling the life preserving oxygen, as bountifully given out by the vegetable kingdom; and we see that one kingdom, in the wisdom and merciful providence of God, is thus made to sustain the other. We know, also, that carbon is one of the sixty-two or three simple elements supplied to us by the same wisdom and power in all-sufficient abundance; but we cannot yet understand the process of its distribution, nor all the movements and changes to which it has been, and is yet subjected. One

thing more, however we do know; that if the incalculable mass of carbon, now fixed and consolidated in mineral coal, were again set free in the form of carbonic gas there would be more than enough to poison the world. We look back therefore to the time when, at the commencement of the coal formation, no oxygen-breathing animal could have lived; and we judge of that period by the fact that no fossil remains of any animal now living out of water have come down to us from the coal period; while the remains of those once living in water, and of the vegetation of that period, are abundant.

Nor is this all. We have already alluded to the fact, that the animal kingdom as it now exists, furnishes to the atmosphere nearly all its supply of carbon, in the form of carbonic gas breathed from its innumerable lungs; while on the other hand, the vegetable kingdom yields to the atmosphere in return, its proportion of oxygen for the sustenance of animal life. With these facts, we must connect another, bearing strongly upon this point; and, it is the division of the animal kingdom into two great classes,—first, those animals living upon vegetables; and secondly, those living upon flesh: For it is clear that before the vegetable kingdom was brought into existence by the fiat of the Almighty, no vegetable eating animal could have existed; and consequently, that the second class of animals, living upon flesh, could not have existed until vegetation had reared up a generation of the first, for the latter to feed upon. This seems clear; and I had written just this far when it first occurred to me to test this theory by the order of Creation, as stated in the first chapter of Genesis. My recollection of that order was entirely at fault, and I turned to it with some misgivings, but they were all baseless. In the 11th and 12th verses, the creation of the vegetable kingdom is mentioned; in the 20th verse, the creation of the fishes is stated; and in the 24th the creation of the animal kingdom is described, *commencing* with the *cattle;* as the vegetable kingdom commenced with the *grass* of the field. Surely, no one need ever fear that the truths of the Bible, rightly understood, will ever conflict with the truths recorded or developed by nature, for both have for their author the same Great Being, who "cannot lie;" and if poor Gallileo, and the ignorant Romish Priests who persecuted him for his theory of the earth, had read their Bibles as they ought, they would there have found the truth revealed that the earth is round.* They would have seen that inspiration speaks of it as the *earth ball;*† and also, that "He stretcheth out the North over the empty place, and hangeth the earth upon nothing;"‡ thus revealing deep physi-

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* Ps., 18:15. † Ps., 77:18. ‡ Job, 26:7.

The words in the original Hebrew, found in two verses of the Psalms quoted above and meaning *round* and *ball*, are not translated in our English version of the Bible; but in the

cal truths which Astronomers labored for centuries to discover because they overlooked them in the revelations of their Creator.

We may then return more confidently to examine the vegetation of the Coal period with such lights as we have; and we find strong evidence of its having been most abundant, and of very rapid growth and decay. It was also the production of a much warmer temperature, and a more humid atmosphere than our own; and when we reflect upon its reed and cactus like nature; and upon its rapid growth, and the almost inconceivable amount of it necessary to have formed our Coal Beds; we are deeply impressed with the conviction that the atmosphere of its day was over burdened with carbon, derived, much of it probably, from the disturbed and volcanic earth; for carbonic gas yet bubbles up from many a mineral spring; issues from thousands of volcanic fissures; and the Lake of Solfatara, in Italy, to this day sends forth immense quantities of it from its surface. Traces of extinct volcanic action are visible all over the earth; and though no ancient crater can be pointed out in many sections of its crust, yet the up-heaved rock of our own mountains, as well as others, attest the great energy of the disturbing power to which they have been subjected; and we can thus understand the great probability, that in those early days the atmosphere may have been loaded with carbon sufficient for the rankest vegetation imaginable, while yet there were no animals whose lungs were fitted to breathe an atmosphere so deleterious to the existence of the present races.

The position of our coal beds, with reference to the rocks of the earth, is another subject of interest. Unlike the metals, it is found in sheets of greater or less thickness lying between the strata of rock, and conforming as a general rule to their curves and inclinations. We therefore never expect to find a coal bed extending down to a great depth *through* different rock-layers; but this at one time was not generally understood. There are citizens of Philadelphia who can well remember when the Stock of the Lehigh Coal Company fell twenty per cent. in market, upon learning that their workmen had reached the bottom of their coal at the depth of sixty feet! They little knew that what was lacking in depth was more than compensated by the area of their mine.

An English Geologist says that "Coal Fields are of limited

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earlier translation of the Psalter the first verse quoted is literally translated, having in it the phrase "the *round* world"; but the more cautious translators of the Bible being engaged in that work before the days of Gallileo and therefore not dreaming that the earth was a round ball, may well have doubted whether they understood all the different meanings of those original words, and from over caution may have omitted them in their translation, lest they should lead to material and injurious error. And as to the last quotation from Job—to men, at the time of that utterance, the earth seemed an interminable plain; and who, but God, could then have revealed the fact that the "North was stretched out over the *empty* place"? or that the earth was hung "upon nothing"?

extent, and their strata frequently dip towards a common center; being often arranged in basin shaped cavities which appear to have been originally detached lakes, gradually filled by repeated depositions of carbonaceous and mineral matters." But this statement applies mainly to the Coal Mines of England and the Continent, the only coal fields the writer had seen. This description is applicable to the Anthracite fields of Pennsylvania; but is wrong as to the great Bituminous Coal Fields of the West. There the Coal lies in nearly horizontal strata, and as a general rule presents little of the basin shape, unless it be upon an immense scale, limited only by the Gulf of Mexico, the Great Lakes, the Alleghenies, and the Rocky Mountains. Even in the Allegheny Mountains the Bituminous coal is found near their tops, and passes through from one side to the other nearly on a level. As already intimated, the anthracite coal fields differ from this, and correspond very nearly with the European coal fields.

We are all familiar with the basin shape of this valley; and the southern coal field, embracing Pottsville and Mauch Chunk, corresponds with this, except that it is more elongated in proportion to its width; and though in that part of the middle coal field embracing Hazleton and the neighboring collieries, some of the coal is found upon high table land, yet it lies in the form of basins filled to the edge with earth and rocks. They seem to have formed the *bottom* portions of larger basins; their ancient boundaries or upper portions having been swept away. To this marked difference between the geological features of our bituminous and anthracite coal fields, has been attributed sometimes the difference in the qualities of the two kinds of coal. Viewed geographically, and upon a large scale, the bituminous coal of this country is found to occupy the immense area of country watered by the Mississippi and its tributaries; while the anthracite coal fields of Pennsylvania, in comparison, are mere outlayers and small patches of the larger field, broken off from its edge and contorted by powerful disturbing forces. The coal of the larger field lies comparatively undisturbed, and is bituminous in its nature; but the anthracite has been evidently disrupted, disturbed, and bent into various forms, by which it is supposed its bituminous and volatile matters have been driven off, or suffered to escape. This idea strikes the minds of some as a reasonable explanation of the difference between the coals; but they forget that the bituminous coal fields of England present the same geological features as our anthracite fields; in fact, the English coal has been more thoroughly disturbed by volcanic action, without changing at all its bituminous character. We cannot, therefore, attribute the superior character of the anthracite to a cause which has not produced the supposed result in other instances. The reason why the anthracite is

not bituminous, like its great neighbor, is yet unknown to us; and we must await patiently the further development of facts before we can solve this mystery to our satisfaction. At present we have but one or two leading facts for our guide. We know that where trap rocks in England, have been sent up, in a melted state, *through* bituminous coal beds, their *heat* has turned that coal into anthracite,—sometimes for five or six feet on each side of the trap. We are then taught, that heat, attendant upon the great revolutions in the earth's crust, *has* changed coal from bituminous to anthracite; and the heat attendant upon the ancient disturbance of our coal measures, may have given the anthracite character to our coal. If this, however, be true, why did it not cause all the coal of England to become anthracite, as well as ours? The reason may be this: The Island of Great Britain has evidently been raised up from the depths of the ocean; and if the disturbance of its coal measures occurred during its submergence, water, by checking the attendant heat, may have prevented a change in the character of the coal, except in the particular instances mentioned. But shall we be told this cannot be; that the vegetation which formed those English coal beds could *never* have grown under the ocean? This is true; but there is abundant geological evidence, proving clearly that after that vegetable carbon was formed and deposited, the Island was in fact submerged, and hundreds of feet more of solid rock was deposited in water *above* the coal; and in what water, but that of the ocean?

The geological position of the anthracite is also peculiar. Thorough surveys have been made on every side of us, and the fact is now evident that it occupies the highest strata of our rocks, and seems to have been the latest or youngest formation in this part of the earth's crust. All the other rocks of the earth *here*, seem to be below the coal measures; but this may be called a local peculiarity. To understand this better, we must look at the earth's rocks, and they have been so carefully studied as to admit now of a clear and simple classification in their proper order. The lowest class is what are generally called the primary rocks, embracing granite, the very lowest and foundation of the whole; and also the gneiss and micaceous slate, overlaying the granite, and consisting of the same material. These rocks in Pennsylvania are found near Philadelphia; some strata of the micaceous slate and gneiss being used in that city for flag stones, and may have attracted the attention of some here by their bright and shining appearance, attributable to flakes of mica, so abundant in some of them. These rocks contain no fossil remains of plants or animals, and the granite is generally crystallized.

Over these lie the "secondary rocks," embracing even the coal measures and all below the coal to the primary rocks just

described. But other names are also given to these strata. Taken together, they are sometimes called the "primary fossilifferous" strata, because they are the first class of rocks above the primary, which seem to have been deposited in water, and that contain fossilifferous remains of plants and animals. They are also sometimes called the "Devonian system" of rocks, because they correspond in age and character with the rocks prevailing in Devonshire, in England. The classification of this large group of rocks into smaller divisions is also various.

We find, by examining closely the borders of our valley, that the coal is underlaid—

1. By a conglomerate rock composed mainly of water-washed quartz pebbles, bound together by a silicious cement. This rock varies in thickness in different places from one to two or three hundred feet. Prospect Rock on yonder mountain, so well known to this community, is a fair specimen of its character, and forms a part of it in that direction. It underlies all our coal, and sometimes is in close proximity to it. It forms the basin or trough containing the coal measures; and when we speak of coal measures we mean not only the coal, but all the rock lying between the beds and over them to the surface. We have then from the top downwards, first the coal measures and then the conglomerate.

2. Next below the conglomerate, is a stratum of gray sand stone of ordinary texture, and perhaps one hundred feet in thickness.

3. Next under this, is a thin stratum of variegated lime stone or marble; varying in thickness from two or three, to six or eight feet. It is of a light blue color where it has been quarried, but with numerous red spots, owing to the red sand mixed with it; and this is so abundant as to render it useless for lime. It cannot be so burned as to slack sufficiently for that purpose.

4. Immediately under this lime is found the "old red sand stone" of our quarry men and stone masons. It is old only in comparison with the higher sand stone, for the "old red sand stone" of Europe is far below it. With this stone our streets are flagged. Its thickness varies, but generally it may be set down at two or three hundred feet. It is interesting to examine a piece of this rock, broken across its stratification. Its different layers of different colored sands are then plainly discovered and the whole looks as if we had gone to the pure sand bars of the river and cut out a block of water-washed sand; and as we walk our streets and look down upon these stones we see there, in all their variety, the marks of waves and the gentle ripples that ruffled the surface of those sands countless ages ago, when the earth was being formed, and was gradually assuming its present shape and structure.

5. Lying next below the red sand stone is the "red shale," well known to us for its great thickness—perhaps a thousand feet—and for the readiness with which it yields and crumbles under the effects of frost and water. Thus broken, its debris, at a short distance, resembles broken hemlock bark, and we have a fine specimen of it in the ledge below Nanticoke Dam, on the Susquehanna.

6. Under this "red shale" lies a yellowish green sand stone and other rocks of various colors and qualities, extending down many thousands of feet to the primary rocks already mentioned. They are sometimes called the upper and lower silurian rocks, because they correspond with the rocks of that name in England.

Doct. Rogers, who made the geological survey of this State, divides all of these rocks below the coal and above the primary rocks, near Philadelphia, into twelve classes or varieties; and he estimates their united thickness at 42,200 feet, or about eight miles. They have all been deposited in water; and contain impressions of shells, plants, trees, fish, and animals of the lizard and crocodile type, and nearly all are of species or kinds now extinct.

To describe these different classes of rocks more minutely would be tedious to many, and unprofitable; but we may mention that in their wide range is found the lime stone of the Great Valley, in Chester County; the Schuylkill marble; the zinc ore of the lower Lehigh; and the iron ores of Lehigh, Berks, Lebanon, and Cumberland Counties; with the iron and lime of Montour; and the slates of Lehigh and Northampton. It is indeed a wide range of rock that embraces so large a variety; but it has a character of its own, as a class, well defined by position and fossil records. It is found North-east of this Valley, sweeping around us through Pike, Wayne and Susquehanna Counties; and filling up the whole country northerly of us, between this coal field, and the same primary rocks of the Great Lakes. It is this fact which proves the coal measures to be the highest and latest formation in this region of country. The rocks bordering the South side of the Valley have already been sufficiently described. They all dip to the North, and evidently pass under the coal; and when we go to Dial Ledge, on the North of the Valley, we find the same rocks in precisely the same order, cropping out from under the coal. And as we go up the Susquehanna, or along the North Branch Canal, we meet with them all, at first highly inclined or dipping rapidly to the South, and under the coal, but as we advance they become less and less inclined, until they are nearly level, except where they have been affected by local disturbances.

These, then, are the general geological features of this part of the country; but they are only a part of the geology of Europe. There the same lower secondary formation is found,

including the coal; but over their coal is a large formation of rock called the Tertiary, which hardly exists here, except in distant patches. The Englishman, when he searches for coal, must look far below the upper rocks of his island. He first finds the tertiary rocks; below them the chalk, the green sand, the wealden, three classes of Oolite, the lias, the upper and lower new red sand stone, and magnesian limestone. Under all these he finds the coal, and under that the remaining lower secondary and primary rocks, in character very much as we have described them here. Thus their coal is far below their surface rocks, and they must dig for it, as a general rule, several hundred feet. The exception to the rule is where the coal crops out; but notwithstanding this advantage is afforded them in some localities, their workings sometimes extend to nearly or quite 2,000 feet below the surface.

Here, on the contrary, the coal is near the surface. The beds crop out to day-light in numerous instances, and in many others ascend the mountain sides, and central hills, affording the greatest facilities for mining operations. The structure of such a coal field as this affords a subject of curious and lasting interest. We shall not for a lifetime understand it thoroughly. It is too various and complicated; and yet its general features are easily understood. Within this great basin of conglomerate rock, surrounding and underlying all the coal, and extending sixty miles in length, by four in breadth, lie snugly deposited all our coal measures; embracing not only the different coal beds but the alternating sand stone, clay, shale, and slate rocks, lying over and between the coal beds. This is the general arrangement; but we have within this coal basin, upon a small scale, many of the disturbances, derangements and changes, which seem to have befallen the geological world without.

We have mountains, upon a small scale, within the Valley; and in them we find the strata of rock and coal raised up, evidently far above their original level. Often they are distorted and broken, and sometimes the lower rocks are pushed up through incumbent, but broken and separated strata of rock and coal. It is thus that coal beds are found in a few instances to have doubled over; or to have settled back upon themselves, and swelled into a mass in some localities much beyond their general thickness. The ancient waters have also done their work. In a few instances portions of a coal bed and its accompanying rock are found to have been swept away; and in other places wide gaps have been made in them and again filled by drifts of sand and gravel. But these features are the exceptions to the general rule of regularity and order. They indeed afford subjects of study, and also sources of difficulty, danger and disappointment to the miner; but on the other hand they often facilitate his operations;

bring the coal out to his view, tempting him with its riches, and encouraging him on to great and successful undertakings that he would not otherwise have ventured upon.

These disturbances have given rise to the different modes of working coal; as, first, by stripping off the roof where it is sufficiently thin, and then digging the coal as in a quarry; secondly, by drifts or tunnels at the base of hills; by slopes following the coal down from the out crop; or by shafts sunk perpendicularly upon the coal. Judgment and skill should be used in adopting at each locality the appropriate and most economical and efficient mode; and of all methods, that of the perpendicular shaft is the most complicated, but often the most effective, and economical. The shaft must be large and divided into two divisions by a tight partition of wood or brick. Down one of these divisions the men and cars are always sent for the coal and therefore it is called the "down-cast shaft," by the miners. In the the other division the pump is placed to drain the mine by pumping out the water if necessary; and up this division the bad air of the mine is forced by a fire kept up within its base, and hence it is called by the miners the "up-east shaft." This fire, at the base of the up-cast shaft, creates an ascending current of air through it from the mine below; and the result is, that the fresh air falls *down* the other division to supply the vacuum thus created in the mine. At first the air simply descends the down-cast shaft and ascends the other; and, to be benefitted by it, the workings of the mine must be so commenced, and carried forward, as to enable the workmen to conduct the fresh air through all the working chambers and passages, before it is permitted to return to the up-cast shaft. To this end idle chambers and old workings have to be shut up by partitions of wood or brick. Even working chambers have to be thus closed for the purpose of conducting fresh air to other parts of the mine where it is needed; and this involves the trouble of making doors in such partitions, for the passage of workmen and their cars, on their way to and from the down-cast shaft. These doors when shut must be air-tight; and as they disturb the circulation of the air when open, by changing its course from where it is wanted, they must be quickly opened and shut upon the passage of each car. Small boys, called trappers, are therefore placed at these doors from morning until night, for no other purpose than to open and shut them, as each car shall pass through.

Imagine, for one moment, the condition of a mine of considerable depth and extent, like a few in this country and many in Europe. "It may be many hundreds of feet below the surface, with the workings extended to a great distance; the machinery perfect in all its parts; the mining operations under a regular and rigid discipline; with railways diverging from the down-cast shaft in every direction; the stoppings, passing

doors, brattices, and the whole economy of the mine so arranged, that every part of the work is performed like a well regulated machine. To see a mine of this extent at full work, is a scene of spirited animation; and of wonderful industry. The 'sound of the hammer' is heard in every quarter, and the numerous cars, loaded and unloaded, passing to and from the wall faces to the shaft, are driving and thundering along in every direction. * * * Every one is at his post; added to which there is a degree of cheerfulness pervading the whole scene, which could scarcely be expected in a place wearing so sombre an aspect."

But with all this there are sad drawbacks to these enjoyments. There is death in these workings, to be met with in almost every form. We hear almost every week of sad accidents from various causes; and yet *we* are comparatively free from the most apalling. Notwithstanding all the arrangements for ventilation, here but briefly sketched, mines are often full of the most deleterious gases.

One kind the miners call "choke-damp." It is well known to chemists as carbonic acid gas, and emanates, no doubt, from the coal. It consists of equal portions in volume of oxygen and carbon, and is produced artificially for mineral water fountains, by pouring water and chlorohydric acid upon chalk or pounded marble. It is heavier than common air, and can therefore be collected in open glass jars, and poured from one into another. In this gas fire is extinguished as if dipped in water; and if breathed death is the certain consequence. From its weight, it always occupies the lowest part of the mine; and as it accumulates it rises higher and higher, until the whole mine is filled. It often happens, that when a miner sets his lamp upon the floor of the mine it is instantly extinguished; or in going through some deserted chamber of the mine his lamp, though carried in his hand, is extinguished; and the miner is thus mercifully warned, that he is literally wading through a flood of deadly gas; and that he must escape for his life. When breathed it kills by a specific poisonous influence upon the system; and yet it can be drank in mineral waters; not only with impunity, but with pleasure and advantage.

At the freezing point of temperature, and under a pressure of five or six hundred pounds to the square inch, it is compressed into a clear limpid fluid, not as heavy as water; but which freezes by its own rapid evaporation into a white snow like substance. This is but one fatal enemy of the miner; and once discovered in his workings, immediate measures are taken to drive it out, by changes in the air current of the mine.

Another most fatal gas met with in the coal mines is called by the miners "fire-damp." It is the carburetted hydrogen of the chemist. It is sometimes called "marsh gas," because when the water of a marsh is stirred bubbles of this gas rise to

the surface, and it may thus be gathered in tolerable purity. It is composed of equal parts of carbon and hydrogen, and is only about half the weight of common air; and when mixed with it, can be breathed without imminent danger. It burns with a yellow flame, and when mixed with atmospheric air in the proportion of one of gas to eight of air, it explodes with great force; but fortunately this explosive point of combination is not always attained in the mines; or is soon passed, before accident applies the fatal match. This was the miner's main security, before the days of the safety lamp. If this peculiar combination of circumstances, necessary to produce an explosion, had frequently occurred, the miners would have been driven forever from their work. But they encountered its dangers in another form.

From its lightness this gas rises to the upper part of the mine, and fills its upper chambers, extending down as it accumulates; and if, as in most cases, it is not mixed with atmospheric air to the explosive point, it will yet burn with great fury if fire is brought in contact with it, but without explosive force. The upper part of the mine is then filled with a surging flame; and the miner can only escape if he is under it, by throwing himself flat upon the floor until it is over; and then his peril is only the more imminent. If he is not burned beyond exertion, he must flee instantly from the "after-damp," which immediately follows. This "after-damp" is the same "choke-damp" or carbonic acid gas already described; but the miners call it "after-damp," because it always follows immediately, the burning of the fire-damp, or carburetted hydrogen. The explanation is this. At one moment there may be no choke damp in the mine, but the upper part is filled with fire-damp, not mixed so exactly with common air as to explode; and yet it will burn. In this condition of things a lamp carelessly opened sets the whole in a blaze; and in burning, the oxygen of the air unites with the carbon of the fire-damp, and forms the carbonic gas or choke-damp, which being heavier than the air instantly falls; and if the miner cannot or does not escape, he is suffocated.

Fortunately for us the Anthracite coal does not seem as productive of these gases, as the Bituminous coal of England. We have had here a few accidents, but very few as yet, owing, perhaps in a great degree, to the proximity of our mines to the surface, and their more perfect ventilation in consequence. But in the mother-country these dangers and difficulties were encountered, in all their horrors, for more than a century. "With almost daily misfortunes, of a greater or less degree, the collieries of England were carried on; while every one was struggling against the danger; but with baffled skill, and unavailing precautions. At last an explosion occurred at Felling Colliery, near New Castle, which threw all others before it in

the shade. That mine was 600 feet below the surface, and twenty-five acres of coal had been worked out. Upon the 25th of May, 1812, 121 persons were in the mine and had taken their places at work, when the gas was fired, and a tremendous explosion followed." I quote from a contemporaneous account. It says:—"The subterraneous fire broke forth with two heavy discharges from the deep-pit, and these were instantly followed by another from the rise pit. A slight trembling, as from an earthquake, was felt for half a mile about the colliery; and the noise of the explosion, though dull, was heard from three to four miles distant. Immense quantities of dust and small coal accompanied these blasts, and rose high in the air from the pit's mouth, in the form of an inverted cone.

The heaviest part of the ejected matter, such as corves, wood, and small coal, fell near the pit; but the dust borne away by a strong west wind, fell in a shower at the distance of a mile and a half from the pit. In the adjoining village of Heworth, it caused a darkness like that of early twilight, and covered the roads so thickly, that the footsteps of passengers were imprinted in it. The heads of both shaft frames were blown off; their sides set on fire, and their pullies shattered to pieces. Such were the fearful volcanic effects in the mine and atmosphere. The viewer and his assistants, instantly descended, in the face of the most imminent danger—eager to save as many of their people as possible—but the mine was found to be on fire, and it was impossible to proceed.

Only thirty-two, of the one hundred and twenty-one persons in the mine, were drawn up alive. In consequence of the fire within the mine, another explosion took place, and no other alternative was left but to close the mine, in order to extinguish the fire; although they knew that some of the men within might yet be alive."

To us, this idea is horrid; but we must remember that Bituminous coal burns in the mine, with a facility unknown to us in the Anthracite. Had not the fire in this mine absolutely precluded all progress towards the relief of the lost, the duties of the manager, or viewer, would have still been appalling. The miners' houses are generally not far from the mines; and "the instant an explosion takes place, the alarm is general, and the wives and relations of those in the mine rush to the shaft in a state of distraction; where a heart-rending scene takes place, that can be imagined but not described. All the violent effects of sudden grief, are the consequence. They look to the horrible pit, where those who are most dear to them are entombed, and who, but a few hours before, left them in health and vigor, with the hope of returning happy to their homes.

In such a case, the mining engineers have a severe and imperious duty to perform. The shaft they must descend is either rendered dangerous by the wreck of loose timber torn

away by the eruption, or the air is in a pestilential state; and what is still more alarming, part of the coal may have taken fire from the explosion, or a blower may be lighted, either of which will produce repeated and violent explosions, the instant the gas accumulates to that point and comes in contact with fire. Such a case was not unfrequent, and against this no human skill could guard.

All this had to be encountered by the engineer and his assistants. The hope of saving some of the workmen from death; and the ardent entreaties of the agonized relations, place the consideration of personal safety out of the question.

On descending to the bottom of such a shaft, it is perhaps with great difficulty the mine can be entered, owing to the wreck. If the descending current of air is good, part of the wreck is cleared away. The engineer then considers what are the best immediate plans to pursue, arising from his experience, and his knowledge, not only of the general situation of the workings, but of the direct lines of the air course; so that he may in the shortest time restore the ventilation, and if possible, relieve the miners who may yet be alive. Having formed his plans, he states them to his assistants; and a large quantity of prop wood and brattice boards are sent down, and the party enters the mine as far as the air will allow them; care being taken to have it with them every step as they proceed. As the violence of the explosion destroys many of the stoppings, and almost every door upon the air courses, the whole circulation is laid dead. All these doors must be replaced, and the brattice repaired where torn, as they advance forward with the air; and this work, being in general executed with astonishing quickness, many lives are sometimes saved. The overmen and their deputies often exhibit great dexterity. They will work in the dark with the wreck of one destruction around them, and threatened every moment to be overwhelmed in another; but the hope of saving a fellow-workman from death, gives the liveliest energy to their actions; and if they think that a bold effort will save life, they will rush into the midst of pestiential air, and grapple with death. The mining engineers are always at the head of this service, and as they, with their assistants, frequently push forward in the dark, it is no uncommon thing for them to drop down senseless while those in the rear seize them and draw them back to better air; yet no sooner are they re-animated than the same generous impulse acts in its full force, and they make the same attempt again and again until nature is exhausted; and many fall a sacrifice to their bold and generous exertions. When it is ascertained that fire exists in the wastes; or that the solid coal is on fire, the descent into the mine is rendered tenfold more hazardous, as a moment's safety cannot be depended upon;" for if the discharge of gas is great,

repeated explosions are then sure to follow, and sometimes they have been repeated as often as once an hour. "In such cases no man dare go down, as his destruction would be inevitable;" and the mine must be closed up, as in the case just described, as occurring at Felling. This account is here inserted because it was among the last of the great explosions in England; for that fatal misfortune, aroused the minds of every one connected with Collieries, to discover, if possible, some preventive of such disasters; and they were successful. I need not detail the history of those efforts. It is enough for our present purpose to know, that Sir. Humphrey Davy and Mr. Stephens, at the same time discovered the fact that the flame of a lamp or of a fire, will not penetrate through a small tube however short; and it followed as a matter of course, that as a fine wire gauze, is only a sheet of small adjoining short tubes, the flame of a burning lamp, or of gas burning within such a gauze cover, would not pass through so as to communicate fire to the surrounding gas without; and this is the simple construction, and effect of the celebrated "safety lamp;" called by the miners their "little Davy," in allusion to the inventor. It is made of metal, with closely fitted joints; and instead of glass sides for the transmission of light, a fine wire gauze is used.

With this lamp a miner can walk into the midst of inflammable gas, ready to explode like an immense magazine of powder. In such cases, the first symptoms he discovers of its presence, is the elongation of his lamp flame; and if he persists, his lamp is soon filled with the flame of the burning gas. He then takes the alarm and makes his escape; and immediate measures are resorted to, to expel the gas from the mine. An easy experiment tests the efficiency of this lamp, to a common observer. If a piece of fine wire gauze is placed in the flame of one of our gas lights and within half an inch or more of the point, the flame is cut off by it as effectually as by a sheet of metal. If held an inch or less above the burner, the blaze will not pass through it; but unburnt gas passes through, and may be lighted on the upper side of the gauze, by a candle or match. A tight glass lamp would not secure the miner's safety. It must be open to the admission of air, or it will not burn. If the air is suffered to enter, the gas enters also; and if its sides were of ordinary glass, they would be broken by the heat of the burning gas, when the whole mass would take fire. The same danger exists, but in a less degree, with the wire gauze. If the bearer of the lamp, is unobservant of the warning flame within, or remains too long in the gas, the wire may be burnt out or become so heated as to fire the gas without.

Besides this, the gauze is so fine as to yield but little light. It was a dark lantern, and for this reason miners disliked to

work by it. It was in use, however, from 1815 up to the present time; but in 1849 a great improvement was made upon it. They ventured then to introduce into its sides a ring of thick glass opposite the light, leaving the gauze above the glass as before. This gave the lantern a double value, almost; and yet its great utility consists in their being able to test with it, in safety, the existence of gas in the mine; and if found there, to expel it by a better ventilation. These experiments are made generally in the morning, before the laborers go into the mine; and sometimes during the day at different hours, as the abundance or scarcity of gas may render prudent. With these precautions, by the help of this lamp, few accidents, comparatively, now occur; and, generally, the injuries they now inflict are of limited extent. Before the improvement of the lamp, accidents occurred through the carelessness of the workmen, in throwing open the lantern incautiously, to obtain a better light. But often they received censure, when they in fact deserved sympathy; for besides the gasses already described, there is found, sometimes, in the mines, a mixture of nitrogen gas, which, if long breathed, induces a stupid, dreamy condition of the mind. In this condition, the miner works more by instinct or habit than by judgment. He feels that the air is bad, but not always knowing the reason, works on, and sometimes does things without a thought or a motive. But notwithstanding all these difficulties, they seem small indeed in comparison with the terrible disasters which so frequently happened before the days of the "safety lamp." An English writer has said that its invention produced a new era in the coal mining of England. To science, this country as well as England, is indebted for this useful invention. The benefits derived from this lamp alone are incalculable, and yet the inventor received no substantial reward,—nothing but reputation, and the feeble, fitful gratitude of a few out of the millions whom his labors have blessed. We speak thus of Sir Humphrey Davy, whose scientific knowledge led him to the invention; but Geo. Stephens, then a mining engineer, also invented, by experiment, the same thing precisely, and at the same time. His lamp was also presented for the prize, in competition with Sir Humphrey's, but it had in it the glass ring, and the small prize offered was given to Sir Humphrey—so partially and unjustly, many thought, as to induce a private subscription.

LECTURE II.

In 1762 this Valley of Wyoming was first settled by people from Connecticut principally. They of course soon found coal at its numerous out-crops and exposures. Doubtless they tried to burn it, but could not. Some of them probably, had seen English Bituminous coal; for it was then sold in several sea-ports in small parcels, and for particular purposes; and it was generally called "sea-coal," because it was brought over the ocean. Some of the New England people, who came into this Valley, no doubt were aware of this. They must have known also, that Englishmen had a kind of coal—now known to be Anthracite—which they could not burn; and which, for that reason and its hardness, they called "stone-coal." How natural then that the early settlers here, not being able to burn this Anthracite, should give it the same English name of "stone-coal."

Subsequently to this Obadiah Gore and his brother, came from Connecticut and settled in this Valley. They were blacksmiths, and had their full share of the ingenuity and enterprise, attributed generally to their countrymen. It was not long before they tried this coal in their shop fires, and their success in using it to advantage is well known. This was in 1768–9, as Mr. Gore, himself, informed Judge Fell; so the latter has stated, in his letter printed in Hazzard's Register. After the Gores had succeeded, other blacksmiths tried the experiment, and it was soon used by them throughout the Valley.

Not long after the Revolutionary War commenced an armory was established at Carlisle, in this State; and several blacksmiths and gunsmiths were employed in fitting up arms for the troops. Some of the workmen had, perhaps, used coal in England and desired to use it again. Whether either of the Gores already mentioned were with them is now unknown but it is certain that in 1776, and afterwards during the war, two Durham boat loads of coal were annually taken, from what is now Col. George M. Hollenback's coal mine above Mill Creek, to where Harrisburg now is; and being landed upon the west side of the river was drawn in wagons to Carlisle, and there used in the armory. A Mr. Geer then owned the property where this coal was mined. The late Judge Hollenback purchased it of him about the year 1778;

and but a few years before his decease pointed out the spot where this coal was mined to his son, Col. Hollenback. It was then filled up and quite large trees were growing upon the ground. It was near the bank of the river, below the canal, and nearly opposite the present openings of the mine. Only a few years since Col. Hollenback employed some men to re-open the coal at that place, and in three or four days the old working was found, and convinced him of the accuracy of his deceased father's recollection.

From the Revolutionary War long years elapsed before it was used in grates or stoves. All attempts thus far to use it as a household fuel had failed; but as it burned well upon the blacksmith's hearth, there was a strong feeling among people of intelligence that it ought to be burned upon the domestic hearth. Various were the suggestions made; but as a strong blast of air was supposed to be necessary to its combustion, the thoughts of men were turned to the adoption of some expedient for its supply. Some thought of burning it in grates, such as we now use, by means of an air tube, passing from under the grate through the hearth, so as to let a supply of air come up from below. Others, who thought such a supply would not be sufficient, supposed it might be increased by clock-work machinery, driven perhaps, by a weight or a spring. But the rotary fan was not then in use, and as only the common bellows were thought of, others supposed that the necessary machinery, however simple and cheap, would cost more than the fuel would be worth, and none were willing to try the experiment. Such were the speculations listened to by the children of that day; and well remembered by the most aged fathers and mothers of this. But these speculations were yet to bear fruit. The late Judge Fell, well remembered in this community, was a member of the Society of Friends, and had emigrated from Bucks County to this Valley. For some years he was the proprietor and keeper of the best Hotel in this town, now occupied by Philip Heisz, and situated in Northampton Street. A part only of the old building is left; the largest portion having been torn down and replaced a few years since by a brick addition. For many years, and up to his decease in 1830, he was an Associate Judge of our Courts, and a gentleman of intelligence and probity, highly useful to the community in which he lived; and though of modest, unassuming manners, he possessed a sound judgment, and an enterprising mind and spirit.

He believed that our coal could be burned in grates. He judged correctly that the natural draft occasioned by a fire would be sufficient, if the coal in sufficient quantity were only placed in a proper position. It is rational to believe that these were his views; for the first experiment known to his descendants now in this town, was made with a wooden grate,

very much of the form of those now in use. It is amusing now to think of burning coal in a *wooden* grate; but his logic and economy were based upon sound principles. He reflected, no doubt, that if he could make his coal burn so freely as to destroy his wooden grate, he could then well afford to make one of iron; and could do so without fear of loss or disappointment.

We know not the result of this first experiment, or anything of the particulars; but the inference is reasonable that he succeeded, for his next experiment was more public. One of his daughters, the lady of Col. J. J. Dennis, lately deceased, told me that she well remembered the circumstances attending it. The Judge was a practical man, and something of a mechanic. She recollected his going into the blacksmith shop of his nephew, Edward Fell, and of his working with him most of the day, fashioning his first iron grate.

Late in the afternoon he brought it home, and setting it with brick, in the fire-place of his bar-room; by evening he had kindled in it with oak wood one of the best of coal fires. The interest it excited, and the many visits of curious neighbors, anxious to see a stone-coal fire, were also well remembered by Mrs. Dennis. I was an inmate of her house, when these facts first came to my knowledge. I had taken down from their library a book entitled "The Free Masons' Monitor," and found upon one of its fly leaves, in the clear, bold hand writing of Judge Fell—which I had learned to know from the Records of our County—the following memorandum:

"Fe'b 11th, of Masonry 5,808, Made the experiment of burning the common stone-coal of the Valley, in a grate, in a common fire place in my house, and find it will answer the purpose of fuel; making a clearer and better fire, at less expense, than burning wood in the common way.

Borough of Wilkes-Barre, } [Signed.]
February 11th, 1808. } JESSE FELL."

A memorandum, I may add, most certainly replete with interest; and one which I would respectfully suggest should be engraved upon his monument in our Cemetery.

In confirmation of these facts, Judge Bennett, of this Borough furnished me with the following statement. It is an extract from a brief article upon coal, published in the United States Gazette in May, 1830. It says:—

"A gentleman who had heard Judge Fell describe the progress of his experiment, has mentioned to us, that the Judge fashioned his first grate of green hickory; and having satisfied himself, that the general design was good, he aided a blacksmith in forming an iron grate which he placed in the bar room of his house. As no little amusement had been excited at the Judge's exertions to burn coal, he determined to make

a suitable exhibition of the first attempt in the new grate, and accordingly gave notice to a large number of the most respectable citizens, that on the succeeding evening, his experiment would be tried.

The evening came, the fire was kindled, and the coal burned with unexpected brilliancy; but only two or three of his neighbors came to witness the experiment. The others, supposing the Judge had found the fallacy of his plans, and intended to take a little innocent revenge upon them, very prudently tarried at home, with a view of laughing at those of the invited, who might have been more yielding than themselves."

"If so, we may add, that they were themselves hoaxed by their own suspicious prudence. But "how the Judge succeeded," says the writer quoted, "and what have been the consequences—are not these things written in every room of our city from October to April."

I find that an impression exists in the minds of some in this Valley that the wooden grate was constructed only for a model to guide the blacksmith in making the iron grate. Perhaps this very article above quoted, and published nearly thirty years ago, may have given rise to this impression; but it should be borne in mind that Judge Fell did not so state the fact. In truth, no model was necessary, particularly as the Judge helped the blacksmith himself; besides, if he had decided to make a model, it could have been made just as well, and much easier, of pine; and as we have the Judge's authority for the fact that it was made of green hickory, the inference is almost conclusive that it was not a mere model, but designed to resist the action of the fire as long as practicable, and until the coal should burn it down. It was this experiment only that could have given him that confidence which he exhibited by inviting his neighbors to witness the experiment in his iron grate. He unquestionably knew at the time of his invitation what would be the result, and that he incurred no risk of further raillery upon the subject. This more full account is here given, because the Judge himself, in his letters printed in Hazzard's Register, evidently did not undertake to mention all the particulars, for those letters are more brief than was his verbal statement above quoted.

We have then the important and undoubted facts, that the coal of this Valley was known to its people, and used in blacksmith's shops long before the revolution; that during the war, it was sent down the river, and used at the Government Armory in Carlisle; and that on February 11, 1808, its use in grates, for domestic purposes, was commenced in this town, by Judge Fell. Immediately following this new development of its usefulness, the coal for the supply of this town was brought from Col. Lord Butler's coal bed—now the Balti-

more Company's—two miles distant. The work at that bed was commenced at the out-crop of the coal, and was carried on, by stripping off the roof, and digging the coal as in a quarry. This mode of mining was then adopted because the workmen did not understand, or were afraid to pursue the present mode of working under the rock. Of course this mode of mining was expensive; and Col. Lord Butler's books show, that he was paid three dollars per ton for coal delivered in town. Subsequently, more skillful miners arrived from abroad; and by working under the rock, the cost of coal was cheapened.

At that day, the Hon. Chas. Miner was publishing in this town "The Luzerne Federalist"—the only newspaper then printed in this part of the State. I have had the pleasure of examining its files, but I found nothing published in 1808 respecting coal. Mr. Miner was then a member of the Legislature; and at the time of Judge Fell's successful experiments, he was in Lancaster, attendant upon his public duties.

The first notice discoverable, was in 1810, when William Curry advertised for sale, "An extensive coal bed, situated in Plymouth, one mile from the river," as he said; and as he described himself as a Lawyer, residing there and ready to attend to the business of the profession, we learn how early Lawyers were given to dabbling in coal lands, though they sometimes burn their fingers thereby!

In striking contrast with these facts, is the history of the "coal trade" in the neighboring coal fields. According to a recent writer in Harper's Magazine, it was not until 1810, that Col. Geo. Shoemaker, of Berks County, succeeded in prevailing upon the blacksmiths along the Schuylkill to use the anthracite in their forges. At that very time, coal was sent down the Susquehanna from this valley in arks; and the account books of the late Crandal Willcox, of Plains Township, show that as late as 1814, he sold his coal in Marietta at $8.50 per ton—proving most conclusively that its merits were then highly appreciated, in that part of the State. They had probably learned its value from the Blacksmiths of Carlisle; and were also prepared for its early use upon the domestic hearth.

The history of the trade on the Lehigh differed materially from that on the Susquehanna. According to the same writer before referred to—Phillip Ginther, an old hunter upon the Lehigh, found the coal of Mauch Chunk in 1791. He communicated his discovery to Col. Joseph Weiss, then residing at what is now Weiss Port, six miles below Mauch Chunk. Col. Weiss soon after, obtained the title to about 6000 acres of the land, now comprising the principal property of The Lehigh Coal & Navigation Company; and through the influence of Robert Morris, the revolutionary financier; and that

of Charles Cist, Esquire, then an editor of Philadelphia, "The Lehigh Mine Company" was formed; but it was not until 1803 that six ark loads of coal were started from Mauch Chunk for Philadelphia. Of those six only two arrived in the city, and then their cargoes could not be sold. At length, after keeping the coal on hand for some time, the city authorities were induced to buy it for a steam engine used in pumping at the water works; and the same writer states that "all their attempts to burn it proved unavailing. Disgusted at what they esteemed a nusance, they caused what remained to be broken up and scattered over the foot walks of their grounds; and here and thus ignominously," he says, "terminated, for seventeen years thence ensuing, the operations of The Lehigh Coal Mine Company." And Col. Weiss, according to the same account, labored for years in vain, to induce the blacksmiths of the Lower Lehigh to use it in their forges. The fact was, the Philadelphians and the people of the Lehigh were *behind the times;* they did not take the Wyoming newspaper!—and suffered the natural consequences of such a blunder!

I have been greatly interested in turning over their old files. Politics, and the stirring events of the European and American wars, furnished ample materials for their columns; but home subjects were not forgotten.

In 1813 Mr. Miner was publishing "The Gleaner" in this town; and in a long editorial article from his pen, under date of November 19th, and the head of "State Policy," he urged with great zeal the improvement of the descending navigation of the Susquehanna and Lehigh Rivers. He then said:—"The coal of Wyoming has already become an article of considerable traffic with the lower counties of Pennsylvania. Numerous beds have been opened, and it is ascertained beyond all doubt that the Valley of Wyoming contains enough coal for ages to come."

He then goes on to speak highly of its quality, and says further:

"Seven years ago our coal was thought of little value. It was then supposed that it could not be burned in a common grate. Our smiths used it, and for their use alone did we suppose it serviceable. About six years ago one of our most public spirited citizens made the experiment of using it in a grate, and succeeded to his most sanguine expectations."

Again, in the same paper issued on the 31st of December, 1813, in an article headed "The prosperity of Philadelphia," Mr. Miner wrote of the objects to be accomplished for her advantage:

1. The connection of the waters of the Chesapeake and the Delaware—since accomplished.

2. The connection of the Schuylkill with the Swatara—

since much more than accomplished by the Union Canal; and

3. The opening of a communication from the Susquehanna to Philadelphia, by a road or *railway* from Wilkes-Barre to the Lehigh, and thence by that river to the Delaware, and thence to Philadelphia. "I have visited," he said, "Lausanne and a number of other places on the Lehigh, having particularly in view, to ascertain the real situation of its navigation."

Then, in the next issue of the same paper, there is another editorial by Mr. Miner, headed "Navigation of the Lehigh," and occupying two and a half columns of the paper. In it, he wrote earnestly and at length as to the merits of our coal, as well as to the improvement of the Lehigh. Upon this point, he printed in italics the following sentence: "I say with great confidence, this is the course pointed out, by nature, for the connection between the Susquehanna and the Delaware;" and experience has since verified its truth. He then urged upon the public the improvement in question, on the ground of the comparatively small expense it would require. He was not too sanguine, as the event has proved. On the contrary, he then said: "Our public improvements must 'grow with our growth and strengthen with our strength.' We cannot expect in this young country, having so many points to improve, to equal the old and more populous countries of Europe. I appeal to the judicious men who have witnessed the failure of our grandest plans, if they have not miscarried because they were disproportionate to the necessity and the ability of the country;" and he closed this part of the subject by saying: "*I hope our grand-children may live to see a complete railway* from this *place to the Lehigh*, and a *Canal* from thence to Philadelphia.

This is an interesting passage. It would be interesting to know just how many of Mr. Miner's readers understood at that day, what a railway was. There was not then a railway in existence,—save the "tram roads" in and about the mines of New Castle—and to those who understood this *how much like the merest vagaries of the imagination* must Mr. Miner's *confident hope* have seemed? And yet it has been more than realized. His grand-children have indeed, not only lived to see that *very railway* and canal completed, but he has lived to *see it himself*, finished and in use; and more than this,—he has lived to see, not only that particular railway and canal, but also five *other* railroads and two *other* canals, diverging from this valley to the great coal marts of the country! [And since the above was written, a railroad has been made north, by the side of the canal; two others south to the sea board cities, and beside the Lehigh Canal; and the construction of two others has also been commenced, leading into the valley from different directions and by new routes.]

But the result of Mr. Miner's investigations, and of his explorations of the Lehigh at that early day, was the hope, that even then coal could be got down the Lehigh river to Philadelphia, in arks from Mauch Chunk; and in December of 1813, he, in company with Messrs. Cist and Robinson, of Wilkes-Barre, leased the mines at Mauch Chunk and made arrangements to try the experiment. Mr. Robinson withdrew early from their company.

Of Mr. Miner, I need hardly speak in this community. For a number of years he represented old Luzerne, (then embraeing all of north-eastern Pennsylvania) in the Legislature of the State. Subsequently he represented Lancaster, Chester and Delaware counties in Congress; having for his colleagne Jas. Buchanan, now President of the United States. In 1832 he returned to his early home, and is still with us, enjoying happily, at his "Retreat," the evening of a long and well spent life; the valued friend of all about him; and all are friends of his in return.

Jacob Cist, Esquire, who was associated with him in their Mauch Chunk enterprise, was the son of Charles Cist, who with Robert Morris and others, had formed the "Lehigh Coal Mine Company." He came to this valley in his youth, and commenced the mercantile business in this town; but he was devoted to scientific studies and held a wide correspondence with scientific men. He understood better than any other gentlemen of his day, the geology of this region. Highly appreciating its coal, and clearly foreseeing its importanee, he was ever ready to promote its appreciation abroad; and great reason have his respected descendents in this valley, to bless his honored memory, his sound judgment, and far-seeing fore-cast, verified in his short life, by his wise and ample provision for them in the purchase of coal land.

We speak of these gentlemen thus particularly, because their undertaking was depreciated at the time, and the gentlemen themselves subjected to ridicule, by *those whom their foresight, courage and enterprise greatly benefitted.* But this was no terror to them. Their plans were laid, and hazardous as they appeared to many, they encountered every risk. It is unnecessary to speak of details; it is sufficient to say, that in 1814, the next season after their lease, they started five ark loads of coal from where Mauch Chunk now is—then a perfect wilderness,—but two only reached Philadelphia, so rough and difficult did the navigation of the Lehigh then prove. The principal part of the coal that did reach Philadelphia was purchased at twenty-one dollars per ton by Messrs. White and Hazzard, who then were manufacturing wire at the Falls of the Schuylkill. "But even this price," says Mr. Hazzard, in his account of it, "did not remunerate them for their losses and expenses, * * and they were consequently compelled

to abandon the prosecution of the business. The result, however, is not to be judged of by the dollars and cents which it involved. Their success—for it was a success in the most important point and object—laid the foundation of a great work and a great trade, and set in motion a ball that has never ceased, and never will cease to roll.

Their coal was tried, and successfully tried, by Messrs. White and Hazzard. Its value was fully appreciated by them; and stimulated those gentlemen to undertake the work, which resulted in the completion of that very Railroad and Canal, which had been projected by Mr. Miner. He not only foresaw what might be done; but his inception of the plan was followed by "words fitly spoken;" by publications that had their influence, and by deeds that others shrank from. He not only pointed out, but led the way at the most hazardous juncture, and temporarily, to his own hurt; and that great work now finished proves an enduring monument of the skill, and far-seeing sagacity of those who projected and carried it through. It is really such, for we do not yet realize half its importance; for, were it not for the miserable dog-in-the-manger policy of our State government, in not allowing the enlargement of the Delaware Division to correspond with the Lehigh Canal, sea-going sloops and schooners of 150 tons burden could load our coal at that Railroad, 245 miles inland from the capes, and within 20 miles of this Valley!*

But why is it that six Railroads and two Canals are already constructed, leading from this Valley to the great coal marts of the country? It is the great demand for the article; but upon what is that demand based?

It certainly cannot be wholly attributed to motives of domestic economy; nor yet to the demands of a household luxury, however strong they may be. There is yet a more powerful incentive; and let us see if we can discover what it is. In doing this we must premise that engineers, familiar with the operation of steam engines, can calculate accurately, first the amount of power which a given quantity of coal, burned in an engine furnace, will exert by means of its machinery. This calculation is based upon their experience of this power; and therefore such an engineer, if he is skillful in his business, can tell beforehand, if he knows the quality of his coal, just how much labor a pound of coal will perform; that is, he knows how high the steam, which the pound of coal will generate, will raise a given weight in a given time; and he also knows the value of that power, as compared with the

*Since these pages were written a large portion of this canal has been swept away by flood—all that part of it above Mauch Chunk; and two new railroads have been constructed, along its old banks, partially to supply its place.

labor or the strength of men, when applied to mechanical purposes.

Its application to such purposes may be seen all around us. A few days since, I went into a blacksmith's shop in this town, Mr. Adam Behee's, and there saw a small steam engine, newly erected, and blowing the fires. A small boy was tending it; and the owner told me that its fuel cost him fifty cents a day. His remark was, that "The board of two or three apprentices, before employed to blow those fires, cost him more than the running of that engine; and besides, said he, I will soon have it doing other work for me." Most certainly he will. It will drive a trip hammer that will strike all his heavy blows and ten times faster than he can strike them. It will punch and bore all the holes in his iron; cut out his washers and screw nuts, and make many of his bolts and spikes. It may even help his neighbor; for it can stretch out its long right arm into his carriage and wagon shop; and there saw, and plane, and mortice, and tenon all his timber; and as they now black boots by steam, it may yet, some day, do all his painting! Such is one instance of the application of this power to mechanical purposes; and now let us examine its value.

Professor Rogers, the Geologist, late of this country, has recently accepted a Professor's chair in the University of Glasgow, Scotland. His attention has thus been called to this subject, in reference to the English Coal and Manufactures, and he estimates the mechanical power of 5,000 tons of Bituminous Coal, to be equal to the life-labor of more than 1,600 men; that is, he ascertained the fact, that 5,000 tons of coal will exert as much power, while being burned under a steam boiler, as 1,600 men can exert during their whole lives; allowing them all to work with usual industry and the average number of years which experience allots to man.

"Then," he says, "assuming, for calculation, that out of the 65,000,000 of tons annually consumed in Great Britain, ten millions are applied to mechanical power; and we have the fact, that England annually summons to her aid, what is equivalent to an army of 3,300,000 fresh men, pledged to exert their fullest strength, through 20 years of their lives; and therefore her actual, annual expenditure of power, in manufacturing and machinery of every kind, is equal to 66,000,000 of able bodied laborers." *Sixty-six millions* of willing and energetic—but unclothed, unwhipped, and uncomplaining—slaves, are daily at work for her! and I would commend this great, heart-stirring fact, to the very serious consideration of every Abolitionist; and not only so, but to the thoughtful contemplation of every Republican and Democrat in this broad land North and South, East and West.

This, it has been said a thousand times, has made old England what she is. A little Island, stretching far North into

the latitude of Hudson's Bay, she has yet, by the help of this very power and her indomitable will, once nearly subsidized and conquered the world; and raised up an empire in three quarters of its expanse, on which the sun never ceases to shine.

And how does she appreciate this instrument of her power? Her Bituminous Coal, ranking first with her, as our Anthracite does with us, underlies nearly one-third of her soil. She has enough of it in her Island home, to last her a thousand years,—to say nothing of a larger proportion in Ireland hardly touched—and yet, when her coal land is in market, from two to five thousand dollars per acre are the current prices. Her coal market—the whole area of her island—contains 88,000 square miles, and 21 millions of people; and for their supply she has about 8,139 square miles of coal land.

And if we now turn from these facts and figures to our own country, what do we behold? In the first place, our Bituminous Coal is west of the mountains; and on account of the superior quality of the Anthracite, we will not use the Bituminous as long as the Anthracite lasts. The Anthracite is east of the mountains, and therefore nearest the sea-board and the eastern market. If we look on the map of our country, we see that all of the six New England States; New York, New Jersey and Delaware; together with a third of Pennsylvania, and all of the country south below the mountains, is dependent upon our Anthracite; and will be as long as it lasts. If we then look at the statistics bearing upon the subject, we find the area of country thus described, containing 320,000 square miles; and in 1850, 11,635,000 inhabitants, and only 437 square miles of Anthracite, to supply them.

But some may say, that this large market will also be open to the Bituminous Coal; and that Virginia and Western Maryland, is even now supplying it in competition with the Anthracite.

It is true, that some of the Bituminous Coal must be used in the numerous gas works, and for a few other particular purposes; but it bears no competition with the Anthracite. The former is abundant upon the West Branch, within fifteen miles of the city of Williamsport; and yet that town has been fully supplied with Anthracite from this Valley, one hundred miles distant. Two years ago, I found the Anthracite from this Valley was retailed at Chicago and Milwaukee at twelve dollars per ton. From Buffalo it had been carried to those places in returning grain vessels; and had been carried by and around the abundant Bituminous Coal of Ohio and Michigan. It had been carried around, from Carbondale to Rondout on the Hudson, and by the way of Albany to Buffalo; and our North Branch Canal once in operation, it may be sup-

plied at Buffalo certainly as low as six dollars per ton. We can hardly calculate now, how much of this coal will then be sent from that city, nor how much more must be sent to Canada; and yet all must admit, that it will greatly exceed the quantity of Bituminous Coal which can possibly be sold upon the sea board.

It can therefore be said, with entire safety, that the Anthracite of Pennsylvana must supply all of the market heretofore described; and it is a market embracing an area of 320,000 square miles, containing a population of 11,635,000, and fast filling up with many millions in addition.

England, on the contrary, has a coal market embracing an area of only 88,000 square miles, and a population of 21,000,000; but instead of only 437 square miles of coal, she has 8,139 square miles for her supply; and yet she values her coal land, whenever it is for sale, at sums varying between two and ten thousand dollars per acre. It is difficult to retain all these data in the mind at once, so as to comprehend clearly the relative bearing and importance of each. The eye may help the mind to accomplish this;* and the mind itself can grasp the whole subject more effectually perhaps, in the form of a mathematical problem, than in any other way. These data, by reducing the coal area of each country from square miles to acres, are susceptible of such a form, and it is this:

If a population of twenty-one millions, value 5,209,000 acres of coal land at $2,000 per acre; what should a population of 11,635,000, having the same wants in proportion to number, value only 279,680 acres of coal land at per acre?

Who will solve this problem satisfactorily to himself? The facts bear out its terms with all the force of mathematical truth. It is to be observed, that in stating this problem, the lowest price of the English coal lands is adopted as one of its terms. This leaves a wide margin against the hazard of error. England too is much nearer her maximum of population, manufactures, and coal consumption, than we are; while our coal market, in area four times as large as hers, but with half her population now, is rapidly filling up with coming millions. How is it possible then, that we shall err in fearlessly working out the problem proposed? It has been solved, and the solution gives to our Anthracite the value of $20,636 dollars per acre?

Now I do not pretend to say, that there are not some who might be *persuaded*, just now, to take a *little less* than that sum per acre! Perhaps they would be willing to "throw off" the odd $636, and accept only the $20,000! But if any one

*See diagram on 49th and 50th pages.

seriously doubts the mathematical solution, let him test its accuracy by another process.

A coal mine is always estimated by practical men engaged in the business, to yield one ton, gross weight, for every cubic yard the bed contains, provided the coal is all taken out; and to allow one-third of the coal, to be left in pillars, or walls to sustain the roof. But if we take these data as a basis of calculation, we shall again run into large figures. Let us therefore test the accuracy of every step as we proceed.

It is true that a cubic yard of coal has never been cut out of a mine in one piece and weighed; but there is a more accurate mode of arriving at the same truth. Pure water is always taken by mineralogists as a standard of specific gravity; and when a new mineral is under examination, almost the first inquiry is—What is its specific gravity? We do not ask what is its weight; for if we were told that the specimen in hand weighs two ounces, the statement would be inconclusive and unsatisfactory. What we want to know, is its *comparative* weight; whether it is heavier or lighter than iron, or gold, or silver, or water; and mineralogists always use water as a test because of its unchangeableness. It is never the heavier for being too damp, or the lighter for being too dry; and besides, with its help the specific gravity or comparative weight of a min eral is easily tested. We have only to weigh a small specimen of the mineral in the ordinary way, with delicate scales, and note its weight in air, as it is called. Then, the same specimen is suspended from the same scale, perhaps by a hair, and lowered into water and weighed again, and its weight *in water* is again noted. Of course it weighs much less in water than in air; and the difference between the two weights is the important point to be ascertained; for if the number of grains which it weighed out of water, is divided by this difference, the quotient shows its specific gravity, or its weight compared with water. Now, as the weight of a cubic yard of water is exactly known; and also the specific gravity of Anthracite Coal, it is very easy, by a few figures, to ascertain the exact weight of a cubic yard of coal, as it exists in the bed,—and more accurately than it can be done by cutting out a cubic yard from the bed, and weighing it. It is by this nice and mathematical process, that a block of coal one yard square every way, has been found to weigh a trifle over 2,700 pounds net. When therefore, for purposes of business, a cubic yard of coal in the bed is assumed to weigh a gross ton of 2240, the large margin of 460 pounds—nearly one forth—is thrown off as an allowance for waste. Again, a few other figures prove, that in each foot of the thickness of a coal bed, there are, upon the above basis of calculation, 1613 tons of coal to the acre; and if from this, the 113 tons are also thrown off for waste, and the product of the mine is taken at 1,500 tons per

acre for each foot of its thickness a large allowance for waste is most certainly made. The united thickness of all the workable coal beds known in this coal field, is estimated at sixty feet; and if this thickness be taken, an acre, upon the foregoing calculation, will yield 90,000 tons, which, at a rent of only twenty-three cents per ton, would yield an income of $20,700 per acre. And if as usual among Colleries, one third of this coal is allowed to cover the waste of the present most wasteful mode of working coal; and the amount is thus reduced to 60,000 tons per acre, then a rent of 34 cents per ton, will pay the price called for by the solution of the problem. It is also to be remembered, in connection with this, that coal rents have ranged in this country from 25 to 50 cents per ton; and these calculations are made only to show, that in every point of view, the enormous sum of $20,000 per acre, is not beyond the results of mining experience in many instances. Men are known in this Valley, who, in working their own coal, have realized more than $4,000 per acre, from a single bed of twelve feet in thickness. These facts are detailed, not to prove that our coal will be purchased in our day at $20,000 per acre; but to show that its intrinsic value is not at this day at all appreciated; that it is far more likely than anything else, very greatly to rise in its market price; and by and by to attain prices which now would seem exhorbitant, *but for the facts here referred to.* Coal land has been sold here for nearly $1000 per acre, and purchased by men thoroughly acquainted with the business, and working the same coal near by. That land cannot now be purchased for anything like that sum; and there is much land besides, in the same situation; yet, various circumstances conspire to place in market other land; perhaps just as rich in coal, and worthy of high regard. Land here has been, and is yet, divided among many owners, the most of whom are *farmers;* and many are slow to recognize the bearing and force of such facts as we have been considering. A few are constrained to sell as they best can; and many have labored upon their farms their whole lives and feel that they are not yet wealthy; that their day of labor has almost or quite passed away; that they have not yet laid up a store to live upon through the evening of their days; and it may often be that they have children grown up, impatient to begin life for themselves, and to have something to begin life with. To many, influenced by some or all of these considerations, fifteen, twenty, or thirty thousand dollars, seems a large sum of money; a fortune in fact, which they once never expected to realize, and the temptation is irresistible. If they knew the same property would sell for five times as much, ten years hence, they would yet sell at present prices, for at the end of the ten years they may be in their graves; and as happiness is the object of life, they may act wisely for them-

selves,—while others, in purchasing their property, may act with *more than equal wisdom*, as justified by their own objects and circumstances. Great diversity of views, feelings, and circumstances, always exist in a population so large as this Valley contains.

Temporary disasters in the business of the country also affect the hopes and confidence of many unduly; and for a short period depress prices below a reasonable standard. Experience of the past should correct this error.

For thirty years the coal business has been rapidly growing; and yet very often it has been greatly depressed for a season, but always rose the next beyond any season before it. In 1820, the Anthracite coal trade was a new business in this country upon the sea-board. Only 365 tons were sold that year in Philadelphia. It was sent down from Mauch Chunk. In 1825, the Pottsville coal was introduced, 1840 tons being that year sent down the Schuylkill canal.

In 1830, the trade reached the amount, in round numbers, of 175,000 tons. In 1834 there was a reduction in the sales of 111,000 tons, in comparison with the year before; but the very next year the sales reached 360,000 tons, recovering not only what was lost the preceding year, but surpassing the sales of 1834 by 73,000 tons.

In the years, 1838, 39 and 40, there was less coal sold per annum than in 1837, owing to the depressing effects of a low tariff; and yet in 1840 the sales were four times as large as in 1830. Upon the passage of the tariff of 1842, the sales of coal rose in 1843 to 1,100,000 tons, while in 1840 they were only 865,000, and less than in 1837.

In 1850 there were sold 4,800,000 tons; again more than four times as much as was sold the tenth year previous. In 1857, closing the first of January last, (1858,) there were sold 6,765,000 tons. At the same rate of increase in 1860, about ten millions of coal will be sold; much more than double the quantity sold in 1850. But these figures, it must be borne in mind, are confined to the sales of Anthracite coal, north, south and east of us; and do not include about a million tons sent down the Susquehanna, from all three of the Anthracite coal fields. We may safely estimate therefore, that not less than 50 per cent. additional will be wanted in market ten years from this time; and much more we believe, from the indications to be mentioned hereafter; and if 15 millions shall be then demanded the present generation of miners must be industrious and enterprising indeed, if they supply it. In fact another generation equal to theirs must come up to their help; and whoever lives to see that day will see enormous annual incomes realized by coal owners—incomes that now would be thought fabulous. It must be so; in the providence of God it cannot be otherwise.

Great changes in the business itself will occur. The idea of conducting it upon borrowed capital and small means must be abandoned. A ton of coal in market, may well be looked upon with interest. It has cost the seller perhaps four dollars, and at least $3,50 of it is made up of *labor put upon it;* 50 cents only, representing its value in the mine. It is labor too that ought and must be paid for long before the coal is consumed; and this swells to a large amount the capital necessary to be advanced for its production. The working season of its producers commences early in the spring, when the demand for coal is comparatively small. The retailer of the article hesitates to purchase largely. To do so requires a large outlay of capital; and unless he can make an extraordinary bargain, he prefers to buy late in the summer or fall even at a higher price when he can buy upon a rising market and is sure of speedy sales.

The producer must therefore have an abundant capital to do business profitably. He must keep his company of laborers in regular employment upon living terms. He must not be compelled to sacrifice the product of his labor to raise money. He should be able to work through the season, and to wait calmly and confidently for the demand and the remuneration that must come as certainly as the frosts and cold winds of winter. Therefore it is that associated capital must be mainly employed. An individual, or an energetic, skillful firm, with abundant capital, can always mine more cheaply than corporations from their closer and more vigilant attention to the details of business. They can save and make money, at times, when a corporation would lose; but very few firms can be got up with sufficient capital for such a purpose.

But while incorporated companies may not work so economically as firms or individuals, as a general rule, they have a compensating advantage in their division of labor. It is only the spare funds of the merchant, manufacturer, lawyer and capitalist, that are thus invested; the spare funds of the many, under the control of the few, that are thus employed; while their owners are at the same time pursuing their regular business. They are content therefore, and may well be satisfied with comparatively small direct profits upon such spare funds; for that direct profit is not all of the harvest they reap. In the first place the economy and comfort of their own households are greatly promoted by the cheaper supply of coal. Manufacturing of all kinds is greatly increased by it; and of course the mercantile and every other business is enlarged in consequence. The coal business itself adds a large and profitable item to the business profits of all. Who, indeed, is not profitted by the three or four dollars worth of labor put upon each and every ton of the millions of coal sent to market? Even the Coolies of India, who gather up from the ground the

saltpetre worked into the powder that blasts out the coal are benefitted; and so are the ship builders, the ship merchants, and the sailors who bring it home; the manufacturers and merchants who fit out the ships and supply them with rations and cargoes. But it is impossible to trace out all the individuals whose labor or business contributes to place a ton of coal in market. The ramifications of this interest extend wide and broadcast over the whole world. The farmer and the miller upon the upper Missouri; the whaler amid the frozen Ocean of the North, who sends his oil to light the lamp of the miner; and the hunter upon the Pampas of South America, who chases down the wild ox and sends his hide to make the miners' brogans; all participate in this growing and commanding interest.

These facts impress their influences deeply upon the judgment and business movements of the country. They account for the expansion of mining operations, and the rapid formation of mining companies. But most of them are new in the business, and have some things to learn. Improvements in the mode of conducting the business must be adopted. A larger class of coal brokers is wanted to sell coal in the cities; and this class is rapidly growing up and becoming an important class in the trade. Only a few of the many companies can have landings and yards in the cities, for the sale of their own coal, and it must be the business of the coal broker to search out the larger purchasers of coal; to go between them and the sellers, and for a few cents per ton, bring them to terms.* The broker must also labor—as the producer cannot—to learn the true condition of the market from time to time. For his own interest the broker must know who are the purchasers of coal, and the nature and extent of their wants; and they then can and will counsel the producers wisely, as to the extent and nature of the demand; for they must know the producers also, and what, and how much each can supply.

There must also grow up within the coal fields a larger class of mining engineers. Their knowledge of the business should be extensive and varied. They should understand the geology of the coal field in all its details, most thoroughly. They must also understand fully and minutely everything in relation to underground workings; and not only so, but they must be ingenious and practical machinists and mechanics; comprehending accurately all the minutiæ of machine operations. Such a class is already forming and it should be helped forward. The Polytechnic School of Philadelphia should be transferred to this Valley for six months of the

*The remuneration of coal brokers now ranges from five to forty or fifty cents per ton—the lion's share of the profits. Surely more competition is wanted in that branch of the business.

year; for theory without practical knowledge is of little avail. It will not do for mining and iron companies to trust to the advice of half formed engineers, though the entire labors of such an one is engaged for the year. The interests at stake are too large to be thus hazarded. That business must become a profession of large importance; and the most ingenious, skillful and experienced few must be consulted by the many. They must be men of prudence and integrity; and a liberal reward will follow them. No mining operation should be commenced without the advice of such a man. His local, geological knowledge, should counsel the position of the shaft. His mechanical knowledge should plan the machinery. His mining experience should lay out and control the underground workings; while his practical knowledge of each branch should determine the terms of contract for the whole, so accurately and justly that each party shall "live and let live."

The system of employing mining agents must also, as a general rule, be abandoned. I know among that class, men of skill, and of most worthy energy and faithfulness; but as a class they are poorly paid, and their hopes are limited. Now if this class of men—or many of them—were made contractors; if under the advice of a skillful and upright engineer they were allowed a fair price for mining and delivering coal; the business would be better done and with less money. If they were paid monthly and regularly they would need little or no capital to commence. All their energy and skill would be aroused and applied. They would economize in every practicable way; and the coal would be produced to the owners at less cost than under the present system; and at the same time a small profit upon each ton, would liberally reward and enrich the contractor.

Some such changes in the coal business must occur sooner or later; and the sooner the better. A clock-work regularity and certainty will then more largely pervade in all its branches, and all engaged will have their reward. The hearts of lookers-on and sufferers would not then be wrung by the gross waste of hundreds of thousands. Men will then know what they are about. They will find the coal measures the most important and profitable measures of the country. They will find their coal strata the safest and most profitable banks for investment; and the stocks of coal thus laid up for man, far more safe and profitable than the paper stocks of Wall Street.

The indications of an approaching and unusual increase of the coal business have already been alluded to. The fact has also been mentioned, that when prices have been low, and the business bad for one season, the business has always advanced the more rapidly the next; and there is a reason for this. The low prices of coal extend and stimulate its use. When-

ever it happens to be a drug in market, then it is that resolutions are taken, plans formed, and preparations made to use more of the article in future. And now, beyond all this, there are extraordinary indications of an unprecedented increase. The laboring manufacturers of England, and the Continent have been landing upon our shores in thousands, until their labor is nearly as cheap here as in Europe; and tariff, or no tariff, the steady progress of our manufactories can now hardly be stopped.

The late revulsion of 1857 has taught us a lesson as to imports, that will be profitable for us to remember; and it has proved the existence of abundant capital in our country, that hereafter cannot be hid. It must and will be employed. The manufacture of iron, particularly, must advance in accelerated ratio. Skill and ingenuity have been brought to bear upon it until it has cheapened in its *manufacture* here, perhaps below the necessity of a tariff. If not, the Government will aid them by a better tariff. It always has done so when the crisis required it; for the interests of the working classes demand it of the Government more imperatively than any other. If *manufacturers* are not encouraged to work, many thousands of poor laborers are turned out of employment only to suffer for the folly of politicians. The wealthy can do without a tariff, but the laboring classes cannot. In times of pecuniary trouble the fortunes of the wealthy are magnified in honor, profit and power; and it speaks well for human nature, that they are generally willing to forego these obvious advantages, and to pay in the shape of duties, far more than their own numerical share of the public burdens, for the good of the greatest number; and in this respect the Planter of the South and the rich Banker and money lender of the North are financially upon equal terms, but whether equal in liberal patriotism is for their conduct in such times to attest. Besides this our Government in its recently constructed buildings, has used 40,000,000 of pounds of iron. They are models of stone, brick and iron edifices perfectly fire proof; and in this last respect are being followed in the cities by private capitalists and builders. Their numerous iron fronts prove this; and it is indeed a folly to construct in a city a valuable building, in such a manner as to render it almost certain some day to be burned. The interest upon the additional cost of iron, to make it perfectly fire proof, is at once paid by increased rents, and by insurance saved, to say nothing of the perfect safety of the immense amount of property within. The day is near at hand when private interests and perhaps city authorities will demand this use of iron.

A few years ago, Clipper built vessels were the master spirits of the great deep. They originated with us, and Englishmen were compelled to buy them of us, or loose their as-

cendency upon their boasted ocean home. But the tables are now turned. They are now building iron steam propellers, that are fast driving our wooden walls from the sea; but *Jonathan* can never submit to such a result; he will never yield his share of that strip of common territory to a rival. He will build his own iron steamer, if he cannot buy at a bargain; and he will buy at a bargain until he can build; but whether he builds or buys he must freight his steamer with Anthracite Coal; and many a mariner will yet look out upon the great deep from his castle of iron, and thinking well of the coal beds of Pennsylvania; he will long for their contents, as for bread that must be cast upon many waters. The mercantile and armed marine of the world will yet be moved by coal, and when the thoughts and the attention of business men shall be turned to the source of supply, and like the Railroads and Canals, be concentrated upon these little fields of Anthracite—mere specks upon the geological chart of the world—who shall estimate their value, or say that they shall last forever.

ANTHRACITE COAL TRADE

OF PENNSYLVANIA.

The following table exhibits the Anthracite Coal sent to market from the different regions of Pennsylvania, from the commencement of the trade in 1820 to 1868, inclusive.

Year.	Tons.	Year.	Tons.
1820	365	1845	2,013,013
1821	1,073	1846	2,344,005
1822	3,720	1847	2,882,309
1823	6,951	1848	3,089,238
1824	11,108	1849	3,217,641
1825	34,593	1850	3,221,136
1826	48,047	1851	4,329,530
1827	63,434	1852	4,899,975
1828	77,516	1853	5,097,144
1829	112,083	1854	5,831,834
1830	174,734	1855	6,488,097
1831	176,820	1856	6,751,542
1832	363,871	1857	6,431,378
1833	457,748	1858	6,524,898
1834	376,636	1859	7,517,516
1835	560,758	1860	8,143,938
1836	684,117	1861	7,621,354
1837	879,444	1862	7,499,552
1838	738,697	1863	9,427,619
1839	818,402	1864	9,998,646
1840	864,384	1865	9,488,396
1841	959,973	1866	12,055,797
1842	1,108,418	1867	12,216,215
1843	1,263,598	1868	13,405,016
1844	1,630,850		

But for the long "strikes" of workmen, and the consequent high prices of coal, the production would doubtless have reached fifteen millions of tons in 1869.

The production of coal in England

In 1835 was	26,000,000	tons.
" 1850 "	49,000,000	"
" 1865 "	98,000,000	"
" 1866 " in the United Kingdom	101,630,544	"

This only shows the accelerated increase of the coal business in that Kingdom; and that it is *still* increasing more rapidly than heretofore. The *export* of coal from England has now reached nine millions of tons.

AREA AND MARKET.

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Area of the market (320,000 square miles) for Pennsylvania Anthracite Coal, shown by these outside lines. Scale same as on next page.

Area of Anthracite Coal in Pennsylvania, (437 square miles) shown, on same scale, by the central figure below.

FOREIGN COALS.

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The outside lines below exhibit the area of market for the English Bituminous Coal, upon the same scale as the preceding figure, and the area of the coal itself, in the center. Area of English coal fields 8,139 square miles, and its market 88,000 square miles.